

1 LLWMA-1 consists of the 218-E-10 Burial Ground. Well 299-E33-34, a downgradient monitoring
2 well, exceeded the critical mean for specific conductance in 2000, but this was related to the nitrate plume
3 with an upgradient source in the northern portion of this LLWMA (Poston et al. 2001).
4

5 LLWMA-2 is located in the 200 East Area and includes all of the 218-E-12B Burial Ground.
6 Upgradient well 299-E34-7 exceeded the critical mean value for specific conductance in 2000. Sulfate
7 and calcium are the major contributors to the increase and their source is not known. However, only
8 0.6 m (2 ft) of water remains in this well, which is at the top of the basalt, and the increases may be due to
9 basalt chemistry. Well 299-E34-7 also exceeded the comparison value for total organic carbon in 2000.
10 Results for volatile and semi-volatile organics were less than detection limits, with the exception of bis
11 (2-ethylhexyl) phthalate at 1.7 µg/L.
12

13 LLWMA-3 includes the 218-W-3A, 218-W-3AE, and 218-W-5 Burial Grounds in the 200 West
14 Area. Indicator parameter data from upgradient wells were statistically evaluated and values from
15 downgradient wells were compared to established values from upgradient wells in 2000. The critical
16 mean value for specific conductance was exceeded in an upgradient well, but is due to increases in sulfate
17 and nitrate from upgradient sources. None of the other wells in LLWMA-3 exceeded contamination
18 parameters during 2000. Several of the wells in LLWMA-3 have gone dry, as the water table continues
19 to decline. EPA, Ecology, and DOE have an integrated groundwater monitoring well network for the
20 Central Plateau. This includes new wells to be installed for the LLBGs.
21

22 LLWMA-4 is located in the 200 West Area and includes 218-W-4B and 218-W 4C Burial Grounds.
23 Indicator parameter data from upgradient wells were statistically evaluated and values from downgradient
24 wells were compared to established values from upgradient wells in 2000. The critical mean value for
25 total organic halides was exceeded in one downgradient well in 2000, caused by carbon tetrachloride from
26 an upgradient source. Groundwater in LLWMA-4 is being actively remediated using pump-and-treat
27 methods.
28

29 **4.6 Biological and Ecological Resources**

30

31 The Hanford Site is characterized as a shrub-steppe ecosystem (Daubenmire 1970). Such ecosystems
32 are typically dominated by a shrub overstory with a grass understory. In the early 1800s, the dominant
33 plant in the area was big sagebrush underlain by perennial Sandberg's bluegrass and bluebunch wheatgrass.
34 With the advent of settlement, livestock grazing and agricultural production contributed to colonization
35 by nonnative vegetation species that currently dominate the landscape. Although agriculture and
36 production of livestock were the primary activities at the beginning of the twentieth century, these
37 activities ceased when the site was established in 1943. Remnants of past agricultural practices are still
38 evident.
39

40 The Columbia River borders the DOE-managed portion of the Hanford Site to the east. Operation of
41 Priest Rapids Dam upstream of the site accommodates maintenance of intakes at the Hanford Site and
42 helps to manage anadromous fish populations. The Columbia River and associated riparian zones provide
43 habitat for numerous wildlife and vegetation species.

1 Large areas of the Hanford Site have experienced range fires that have greatly influenced the
2 vegetation canopy and distribution of wildlife. In 1984, a major fire burned across 800 km² (310 mi²) of
3 the Hanford Site (Price et al. 1986). From June 27 through July 2, 2000, the *24 Command Fire* burned
4 across the Hanford Site consuming most of the shrub-steppe habitat on the ALE Unit, a small section of
5 the McGee-Riverlands Unit, and other southwestern portions of the site. The fire consumed a total of
6 655 km² (250 mi²) of federal, state, and private lands before it was controlled (BAER 2000). These range
7 fires are a component of natural plant succession.

8
9 The Hanford Site Fire Department provides the planning to guide the management of wildland and
10 prescribed fires on the Site. This planning is designed to ensure safety, protect facilities and resources,
11 and restore and perpetuate natural processes.

12 13 **4.6.1 Vegetation**

14
15 Plants at the Hanford Site are adapted to low annual precipitation, low water-holding capacity of
16 the rooting substrate (sand), dry summers, and cold winters. Range fires that burn through the area
17 during dry summers have reduced species that are less resistant to fire (for example, big sagebrush) and
18 have allowed more opportunistic and fire-resistant species a chance to become established. Perennial
19 shrubs and bunchgrasses generally dominate native plant communities on the site. However, Euro-
20 American settlement and development have resulted in the proliferation of non-native species. Of the
21 590 species of vascular plants recorded on the Hanford Site, approximately 20 percent of the species are
22 considered nonnative (Sackschewsky et al. 1992). Cheatgrass is the dominant non-native species. It is
23 an aggressive colonizer and has become well established across the site (Rickard and Rogers 1983). The
24 biodiversity inventories conducted by The Nature Conservancy of Washington (Soll et al. 1999) have
25 identified 85 additional taxa, establishing the actual number of plant taxa on the Hanford Site at 675.

26
27 The Nature Conservancy of Washington also conducted rare plant surveys. The Conservancy
28 found 112 populations/occurrences of 28 rare plant taxa on the Hanford Site. When combined with
29 observations preceding the 1994-1999 inventories, a total of 127 populations of 30 rare plant taxa have
30 been documented on the Hanford Site (Soll et al. 1999).

31
32 Figure 4.21 shows existing vegetation and land use areas on the Hanford Site, prior to the
33 *24 Command Fire* that occurred in late June 2000. Table 4.11 presents a list of common plant species in
34 shrub-steppe and riparian areas.

35
36 **200 Areas Flora.** Waste management areas and crib sites are generally either barren or vegetated by
37 invasive species, including Russian thistle (tumbleweed), tumble mustard, and cheatgrass. Russian thistle
38 and gray rabbitbrush occurring in these areas are deep rooted and have the potential to accumulate
39 radionuclides and other buried contaminants, functioning as a pathway to other parts of the ecosystem
40 (Landeem et al. 1993). Russian thistle, an annual weed, accumulates nitrates and soluble oxalates, and has
41 significant seed dispersion. Vegetation samples are collected annually from the 200/600 Areas and
42 analyzed for uranium, cobalt-60, strontium-90, cesium-137, and plutonium-239/240. The Hanford
43 Integrated Biological Control (IBC) program was established to control the growth of deep-rooted
44 vegetation over contaminated and potentially contaminated waste sites. The program also established

1 vegetation control through herbicide spraying and cleanup activities. The effectiveness of the program is
2 directly related to the timeliness of herbicide application and removal of tumbleweeds, rabbitbrush, and
3 sagebrush.

4
5 The portions of the 200 Areas undisturbed by DOE and its predecessor agencies, but previously
6 disturbed by farmers and ranchers, are characterized as sagebrush/cheatgrass or Sandberg's bluegrass
7 communities of the 200 Area Plateau. Cheatgrass provides half of the total plant cover. Most of the
8 waste disposal and storage sites are covered by nonnative vegetation or are kept in a vegetation-free
9 condition with the use of herbicides, because the plants could potentially accumulate waste constituents.
10 Figures 4.22 and 4.23 illustrate existing vegetation and land use areas mapped prior to the *24 Command*
11 *Fire* for the 200 West Area and 200 East Area, respectively. Early observations suggest the soil structure
12 and seed bank may have been damaged to the point where vegetative recovery will be slower than in
13 other areas, and the resulting community may not resemble the sagebrush-steppe that existed before the
14 fire.

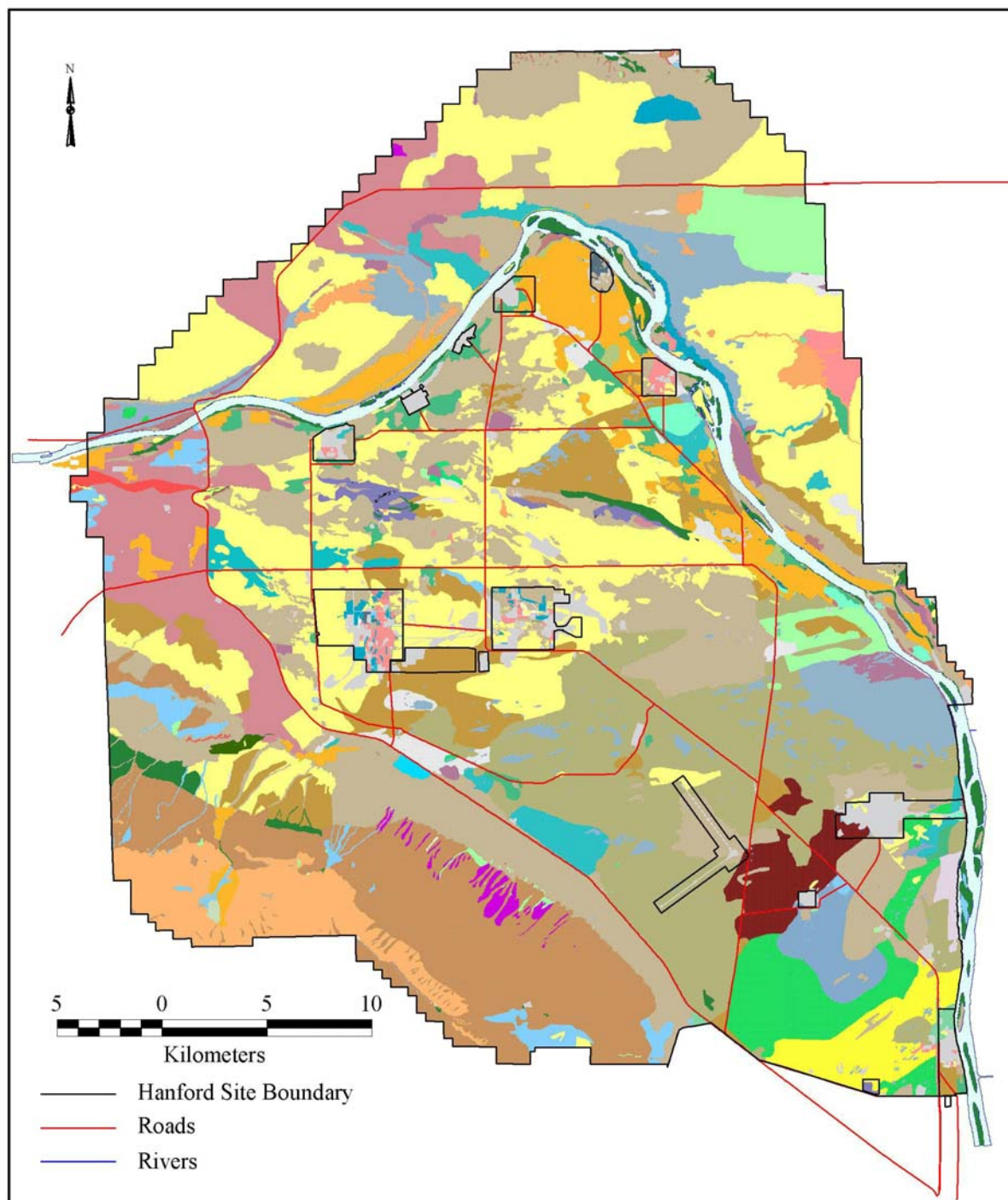
15
16 West Lake and its immediate basin represent a unique habitat that is characterized by highly saline
17 conditions (Poston et al. 1991). Water levels of the pond fluctuate with groundwater levels. Predominant
18 plants include salt grass, plantain, and rattlebox. Three-spine bulrush grows along the shoreline.

19 20 **4.6.2 Wildlife**

21
22 Three hundred species of terrestrial vertebrates have been observed on the Hanford Site. The
23 species list includes approximately 42 species of mammals, 246 species of birds, 5 species of
24 amphibians, and 12 species of reptiles (Soll and Soper 1996; Brandt et al. 1993).

25
26 The shrub and grassland habitat of the Hanford Site supports many groups of terrestrial wildlife.
27 Species include large game animals like Rocky Mountain elk and mule deer; predators such as coyote,
28 bobcat, and badger; and herbivores like deer mice, harvest mice, ground squirrels, voles, and black-
29 tailed jackrabbits. The most abundant mammal on the Hanford Site is the Great Basin pocket mouse.

30
31 Mule deer rely on shoreline vegetation and bitterbrush shrubs for browse (Tiller et al. 1997). Elk,
32 which are more dependent on open grasslands for forage, seek the cover of sagebrush and other shrub
33 species during the summer months. Elk first appeared on the Hanford Site in 1972 (Fitzner and Gray
34 1991), and have increased from approximately 8 animals in 1975 to 900 in 1999. The Rattlesnake Hills
35 elk herd that inhabits the Hanford Site primarily occupies ALE and private lands that adjoin the reserve
36 to the north and west. Elk are occasionally seen on the 200 Area Plateau and have been sighted at the
37 White Bluffs boat launch on the Hanford Site. The herd tends to congregate on ALE in the winter and
38 disperses during the summer months to higher elevations on ALE, private land to the west of ALE, and
39 the U.S. Army Yakima Training Center. Approximately 300 elk have been relocated or removed by
40 special hunts during 1999-2000. Elk relocation continued in 2002. The *24 Command Fire* in June 2000
41 destroyed nearly all the elk forage on ALE. The herd moved onto unburned private land west of the site,
42 to unburned areas on central Hanford, and along the Columbia River near the 100-B/C and 100-K Areas.
43 Post-fire surveys suggest very low mortality of adult elk as a result of the wildfire. However, the wildfire
44 occurred in the middle of calving season, which may have an impact on the number of calves and their
45 survival to adulthood. A cougar sighting on ALE was reported during the elk relocation effort in
46 March 2000.


















































Data Collected: 1994, 1997/The Nature Conservancy
1991, 1999 Pacific Northwest National Laboratory
Map Created: September 1999/Pacific Northwest National Laboratory

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Figure 4.21. Distribution of Vegetation Types and Land Use Areas on the Hanford Site Prior to the 24 Command Fire of 2000 (Neitzel 2002a). Legend on following page.

LEGEND

	Abandoned Old Agricultural Fields
	Alkali Saltgrass - Cheatgrass
	Big Sagebrush - Bitterbrush / Bunchgrass
	Big Sagebrush - Bitterbrush / Needle-and-Thread Grass
	Big Sagebrush - Bitterbrush / Sandberg's Bluegrass
	Big Sagebrush - Rigid Sagebrush / Bunchgrass
	Big Sagebrush - Rock Buckwheat / Bunchgrass
	Big Sagebrush - Spiny Hopsage / Bunchgrass
	Big Sagebrush - Spiny Hopsage / Sandberg's Bluegrass - Cheatgrass
	Big Sagebrush / Bluebunch Wheatgrass
	Big Sagebrush / Bunchgrass
	Big Sagebrush / Needle-and-Thread Grass
	Big Sagebrush / Sand Dropseed
	Big Sagebrush / Sandberg's Bluegrass - Cheatgrass
	Bitterbrush / Bunchgrass
	Bitterbrush / Indian Ricegrass
	Bitterbrush / Needle-and-Thread Grass
	Black Greasewood / Alkali Saltgrass
	Bluebunch Wheatgrass - Needle-and-Thread Grass
	Bluebunch Wheatgrass - Sandberg's Bluegrass
	Bunchgrass - Cheatgrass
	Crested Wheatgrass
	Disturbed
	Gray Rabbitbrush - Snow Buckwheat / Bunchgrass
	Gray Rabbitbrush / Bunchgrass
	Gray Rabbitbrush / Cheatgrass
	Gray Rabbitbrush / Needle-and-Thread Grass
	Gray Rabbitbrush / Sand Dropseed
	Gray Rabbitbrush / Sandberg's Bluegrass - Cheatgrass
	Needle-and-Thread Grass - Indian Ricegrass
	Needle-and-Thread Grass - Sandberg's Bluegrass
	Non-Riverine Wetlands and Associated Deepwater Habitats
	Rabbitbrush / Bunchgrass
	Rigid Sagebrush / Sandberg's Bluegrass
	Riparian
	Riverine Wetlands and Associated Deepwater Habitats
	Sand Dropseed - Sandberg's Bluegrass - Cheatgrass
	Sandberg's Bluegrass - Cheatgrass
	Snow Buckwheat - Bitterbrush / Bunchgrass
	Snow Buckwheat / Bunchgrass
	Snow Buckwheat / Sandberg's Bluegrass - Cheatgrass
	Spiny Hopsage / Sandberg's Bluegrass - Cheatgrass
	Talus
	Threetip Sagebrush / Bunchgrass
	Thymeleaf Buckwheat / Sandberg's Bluegrass
	Vernal Pool
	White Bluffs
	Winterfat / Bunchgrass

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Figure 4.21 (contd). Legend for Figure 4.21

1
2
3

Table 4.11. Common Vascular Plants on the Hanford Site
(Taxonomy follows Hitchcock and Cronquist 1973)

A. Shrub-Steppe Species	Scientific Name
Shrub	
big sagebrush	<i>Artemisia tridentata</i>
bitterbrush	<i>Purshia tridentata</i>
gray rabbitbrush	<i>Chrysothamnus nauseosus</i>
green rabbitbrush	<i>Chrysothamnus viscidiflorus</i>
snow buckwheat	<i>Eriogonum niveum</i>
spiny hopsage	<i>Grayia (Atriplex) spinosa</i>
threetip sagebrush	<i>Artemisia tripartita</i>
Perennial Grasses	
bluebunch wheatgrass	<i>Agropyron spicatum</i>
bottlebrush squirreltail	<i>Sitanion hystrix</i>
crested wheatgrass	<i>Agropyron desertorum (cristatum)^(a)</i>
indian ricegrass	<i>Oryzopsis hymenoides</i>
needle-and-thread grass	<i>Stipa comata</i>
prairie junegrass	<i>Koeleria cristata</i>
sand dropseed	<i>Sporobolus cryptandrus</i>
Sandberg's bluegrass	<i>Poa sandbergii (secunda)</i>
thickspike wheatgrass	<i>Agropyron dasytachyum</i>
Perennial Forbs	
bastard toad flax	<i>Comandra umbellata</i>
buckwheat milkvetch	<i>Astragalus caricinus</i>
Carey's balsamroot	<i>Balsamorhiza careyana</i>
Cusick's sunflower	<i>Helianthus cusickii</i>
cutleaf ladysfoot mustard	<i>Thelypodium laciniatum</i>
Douglas' clusterlily	<i>Brodiaea douglasii</i>
dune scurfpea	<i>Psoralea lanceolata</i>
Franklin's sandwort	<i>Arenaria franklinii</i>
Gray's desertparsley	<i>Lomatium grayi</i>
hoary aster	<i>Machaeranthera canescens</i>
hoary falseyarrow	<i>Chaenactis douglasii</i>
longleaf phlox	<i>Phlox longifolia</i>

Table 4.11. (contd)

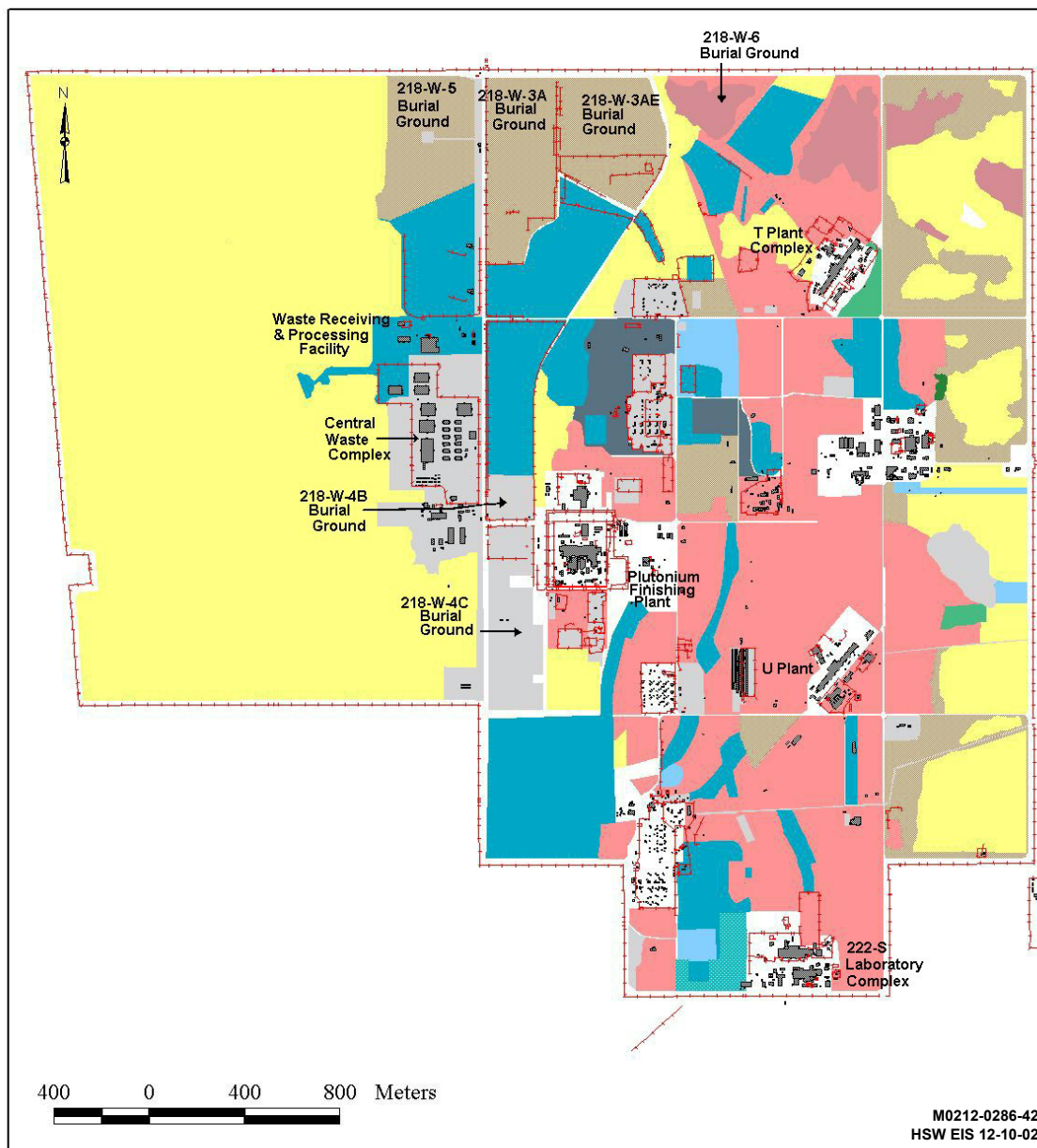
A. Shrub-Steppe Species	Scientific Name
Perennial Forbs (cont)	
Munro's globemallow	<i>Sphaeralcea munroana</i>
pale evening primrose	<i>Oenothera pallida</i>
sand beardtongue	<i>Penstemon acuminatus</i>
stalked-pod milkvetch	<i>Astragalus sclerocarpus</i>
threadleaf fleabane	<i>Erigeron filifolius</i>
turpentine spring parsley	<i>Cymopterus terebinthinus</i>
winged dock	<i>Rumex venosus</i>
yarrow	<i>Achillea millefolium</i>
yellow bell	<i>Fritillaria pudica</i>
Annual Forbs	
annual Jacob's ladder	<i>Polemonium micranthum</i>
blue mustard	<i>Chorispora tenella</i> ^(a)
bur ragweed	<i>Ambrosia acanthicarpa</i>
clasping pepperweed	<i>Lepidium perfoliatum</i>
indian wheat	<i>Plantago patagonica</i>
jagged chickweed	<i>Holosteum umbellatum</i> ^(a)
Jim Hill's tumbledustard	<i>Sisymbrium altissimum</i> ^(a)
matted cryptantha	<i>Cryptantha circumscissa</i>
pink microsteris	<i>Microsteris gracilis</i>
prickly lettuce	<i>Lactuca serriola</i> ^(a)
rough wallflower	<i>Erysimum asperum</i>
Russian thistle (tumbleweed)	<i>Salsola kali</i> ^(a)
slender hawksbeard	<i>Crepis atrabarba</i>
spring whitlowgrass	<i>Draba verna</i> ^(a)
storksbill	<i>Erodium cicutarium</i> ^(a)
tall willowherb	<i>Epilobium paniculatum</i>
tarweed fiddleneck	<i>Amsinckia lycopsoides</i>
threadleaf scorpion weed	<i>Phacelia linearis</i>

Table 4.11. (contd)

A. Shrub-Steppe Species	Scientific Name
Annual Forbs (contd)	
western tansymustard	<i>Descurainia pinnata</i>
white cupseed	<i>Plectritis macrocera</i>
whitestem stickleaf	<i>Mentzelia albicaulis</i>
winged cryptantha	<i>Cryptantha pterocarya</i>
yellow salsify	<i>Tragopogon dubius</i> ^(a)
Annual Grasses	
cheatgrass	<i>Bromus tectorum</i> ^(a)
slender sixweeks	<i>Festuca octoflora</i>
small sixweeks	<i>Festuca microstachys</i>
Trees and Shrubs	
black cottonwood	<i>Populus trichocarpa</i>
black locust	<i>Robinia pseudo-acacia</i>
coyote willow	<i>Salix exigua</i>
dogbane	<i>Apocynum cannabinum</i>
peach, apricot, cherry	<i>Prunus</i> spp.
peachleaf willow	<i>Salix amygdaloides</i>
willow	<i>Salix</i> spp.
white mulberry	<i>Morus alba</i> ^(a)
B. Riparian Species	Scientific Name
Perennial Grasses and Forbs	
bentgrass	<i>Agrostis</i> spp. ^(b)
blanket flower	<i>Gaillardia aristata</i>
bulrushes	<i>Scirpus</i> spp. ^(b)
cattail	<i>Typha latifolia</i> ^(b)
Columbia River gumweed	<i>Grindelia columbiana</i>
hairy golden aster	<i>Heterotheca villosa</i>
heartweed	<i>Polygonum persicaria</i>
horsetails	<i>Equisetum</i> spp.

Table 4.11. (contd)

B. Riparian Species	Scientific Name
Perennial Grasses and Forbs (contd)	
horseweed tickseed	<i>Coreopsis atkinsoniana</i>
lovegrass	<i>Eragrostis</i> spp. ^(b)
lupine	<i>Lupinus</i> spp.
meadow foxtail	<i>Alopecurus aequalis</i> ^(b)
Pacific sage	<i>Artemisia campestris</i>
prairie sagebrush	<i>Artemisia ludoviciana</i>
reed canary grass	<i>Phalaris arundinacea</i> ^(b)
rushes	<i>Juncus</i> spp.
Russian knapweed	<i>Centaurea repens</i> ^(a)
sedge	<i>Carex</i> spp. ^(b)
water speedwell	<i>Veronica anagallis-aquatica</i>
western goldenrod	<i>Solidago occidentalis</i>
wild onion	<i>Allium</i> spp.
wiregrass spikerush	<i>Eleocharis</i> spp. ^(b)
Aquatic Vascular	
Canadian waterweed	<i>Elodea Canadensis</i>
Columbia yellowcress	<i>Rorippa columbiae</i>
duckweed	<i>Lemna minor</i>
pondweed	<i>Potamogeton</i> spp.
spiked water milfoil	<i>Myriophyllum spicatum</i>
watercress	<i>Rorippa nasturtium-aquaticum</i>
(a) Introduced.	
(b) Perennial grasses and graminoids.	

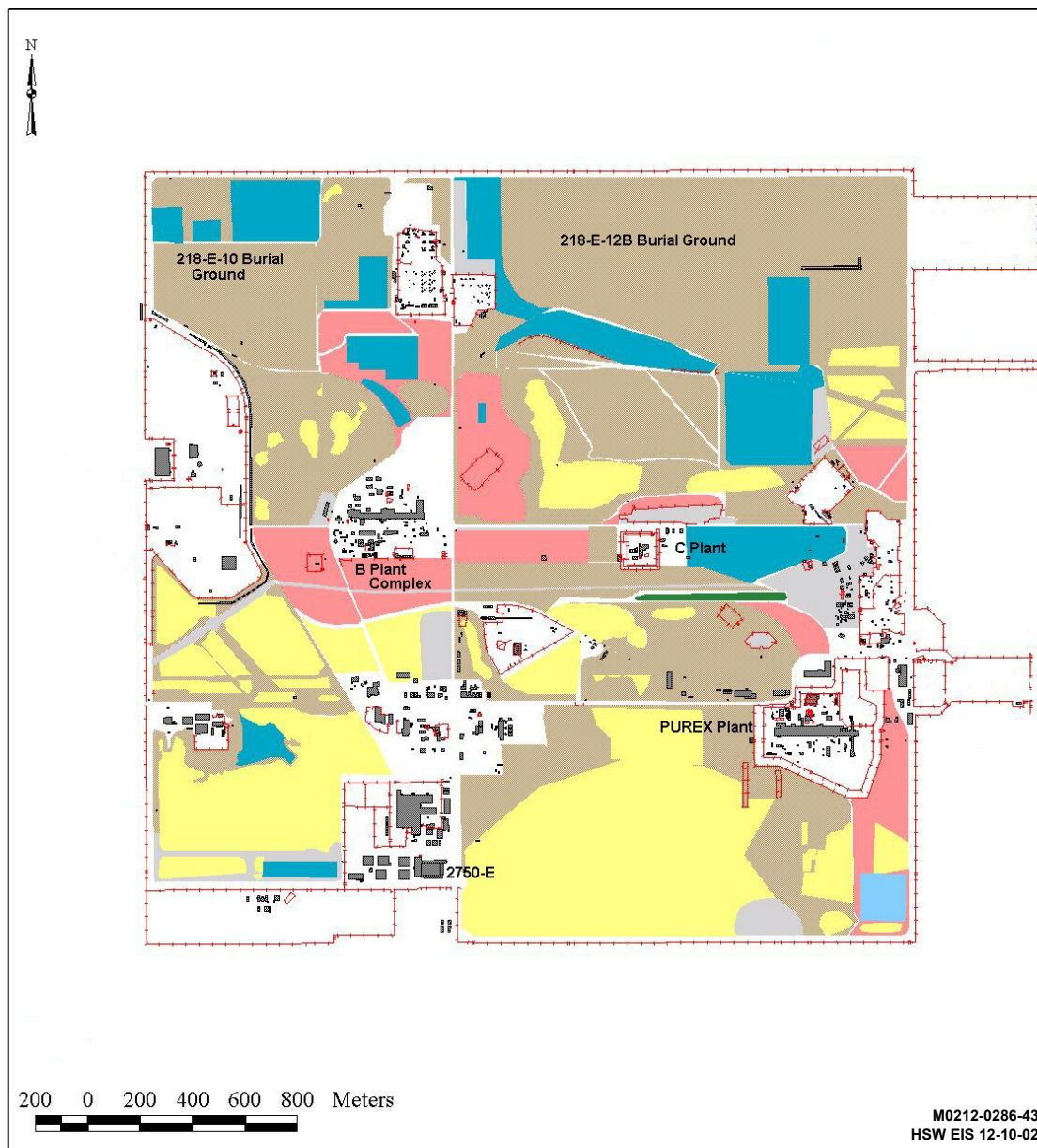


Big Sagebrush - Spiny Hopsage / Sandberg's Bluegrass - Cheatgrass
Big Sagebrush / Sandberg's Bluegrass - Cheatgrass
Bunchgrass - Cheatgrass
Crested Wheatgrass
Disturbed
Gray Rabbitbrush - Snow Buckwheat / Bunchgrass

Data Collected: Spring 1999
Map Created: September 1999/Pacific Northwest National Laboratory

Gray Rabbitbrush / Bunchgrass
Gray Rabbitbrush / Cheatgrass
Gray Rabbitbrush / Sandberg's Bluegrass - Cheatgrass
Rabbitbrush / Bunchgrass
Riparian
Sandberg's Bluegrass - Cheatgrass

Figure 4.22. Distribution of Vegetation Types and Land Use Areas in the 200 West Area Prior to the 24 Command Fire (DOE-RL 2001)



Data Collected: Spring 1999
Map Created: September 1999/Pacific Northwest National Laboratory

Figure 4.23. Distribution of Vegetation Types and Land Use Areas in the 200 East Area Prior to the 24 Command Fire (DOE-RL 2001)

1 Shrubland and grassland provide nesting and foraging habitat for many passerine bird species.
2 Surveys conducted during 1993 (Cadwell 1994) reported the occurrence of western meadowlarks and
3 horned larks more frequently in shrubland habitats than in other habitats on the site. Soll et al. (1999)
4 reported a total of 41 species that are considered dependent on steppe or shrub-steppe habitat. Long-
5 billed curlews and vesper sparrows were also noted as commonly occurring species in shrubland habitat.
6 Species that are dependent on undisturbed shrub habitat include sage sparrow, sage thrasher, and
7 loggerhead shrike. The sage sparrow and loggerhead shrike tend to roost and nest in sagebrush or
8 bitterbrush that occurs at lower elevations (DOE-RL 2001). Ground-nesting species that occur in grass-
9 covered uplands include long-billed curlews, western meadowlark, and burrowing owls.

10
11 Common upland game bird species that occur in shrub and grassland habitat include chukar
12 partridge, California quail, and Chinese ring-necked pheasant. Chukars are most numerous in the
13 Rattlesnake Hills, Yakima Ridge, Umtanum Ridge, Saddle Mountains, and Gable Mountain areas of the
14 Hanford Site. Less common species include western sage grouse, Hungarian partridge, and scaled
15 quail. Western sage grouse were historically abundant on the Hanford Site. However, populations
16 have declined since the early 1800s because of the conversion of sagebrush-steppe habitat. Surveys
17 conducted by the Washington State Department of Fish and Wildlife (WDFW) and PNNL during late
18 winter and early spring 1993, and biodiversity inventories conducted by The Nature Conservancy in
19 1997, did not observe western sage grouse in sagebrush-steppe habitat at ALE. However, sage grouse
20 have been observed on ALE in 1999 and 2000 (Tiller 2000).

21
22 Among the raptor species that use shrubland and grassland habitats are American kestrel, red-tailed
23 hawk, Swainson's hawk, and ferruginous hawks. Northern harriers, sharp-shinned hawks, rough-legged
24 hawks, and golden eagles also occur in these habitats but are not sighted as frequently. In 1994, nesting
25 by red-tailed, Swainson's, and ferruginous hawks included 41 nests located across the Hanford Site on
26 high voltage transmission towers, trees, cliffs, and basalt outcrops. In recent years, the number of nesting
27 ferruginous hawks on the Hanford Site has increased, in part as a result of their acceptance of steel power
28 line towers in the open grass and shrubland habitats.

29
30 Many species of insects occur throughout all habitats on the Hanford Site. Butterflies, grass-
31 hoppers, and darkling beetles are among the most conspicuous of the approximately 1500 species of
32 insects that have been identified from specimens collected on the Hanford Site (Soll et al. 1999). The
33 actual number of insect species occurring on the Hanford Site may reach as high as 15,500. A total of
34 1509 species-level identifications were completed in 1999 and 500 more are expected. Recent surveys
35 performed by The Nature Conservancy included the collection of 40,000 specimens and have resulted in
36 the identification of 43 new taxa and 142 new findings in the state of Washington (Soll et al. 1999). The
37 high diversity of insect species on the Hanford Site is believed to reflect the size, complexity, and quality
38 of the shrub-steppe habitat.

39
40 The side-blotched lizard is the most abundant reptile species that occurs on the Hanford Site.
41 Sagebrush lizards and short-horned lizards are reportedly found on the site, but occur infrequently. The
42 most common snake species include gopher snake, yellow-bellied racer, and Pacific rattlesnake. The
43 Great Basin spadefoot toad, Woodhouse's toad, Pacific tree frog, tiger salamander, and bullfrog are the
44 only amphibians found on the site (Soll et al. 1999; Brandt et al. 1993).

1 With the cessation of production activities at Hanford, the amount of water discharged to the ground
2 in the 200 Area Plateau has substantially decreased. West Lake has shrunk and is presently a group of
3 small isolated pools and mud flats. Avocets and sandpipers still use the site, but it does not support coots
4 or other nesting waterfowl.

6 **4.6.3 Aquatic Ecology**

8 Two types of natural aquatic habitats are found on the Hanford Site: the Columbia River that flows
9 along the northern and eastern edges of the site, and the small spring-streams and seeps located mainly on
10 ALE in the Rattlesnake Hills.

12 The Columbia River is the dominant aquatic ecosystem on the Hanford Site and supports a large and
13 diverse community of plankton, benthic invertebrates, fish, and other communities. It has a drainage area
14 of about 680,000 km² (260,000 mi²), an estimated average annual discharge of 6600 m³/s (71,000 ft³/s),
15 and a total length of about 2000 km (1240 mi) from its origin in British Columbia to its mouth at the
16 Pacific Ocean. The Columbia has been dammed upstream and downstream of the Hanford Site, and the
17 Hanford Reach flowing through the Site is the last free-flowing, but regulated, section of the Columbia
18 River in the United States above Bonneville Dam. Plankton populations in the Hanford Reach are
19 influenced by communities that develop in the reservoirs of upstream dams, particularly Priest Rapids
20 Reservoir, and by manipulation of water levels below by dam operations in upstream and downstream
21 reservoirs. Phytoplankton and zooplankton populations provide food for herbivores such as immature
22 insects that are then consumed by predaceous species. These phytoplankton and zooplankton are largely
23 transient, flowing from one reservoir to another. There is generally insufficient time for characteristic
24 endemic groups of phytoplankton and zooplankton to develop in the Hanford Reach. No tributaries enter
25 the Columbia River during its passage through the Hanford Site; however, there are several irrigation
26 water return canals that discharge into the river along the Franklin County shoreline.

28 Gray and Dauble (1977) listed 43 species of fish in the Hanford Reach of the Columbia River. The
29 brown bullhead, collected since 1977, brings the total number of fish species identified in the Hanford
30 Reach to 44. Of these species, chinook salmon, sockeye salmon, coho salmon, and steelhead trout use the
31 river as a migration route to and from upstream spawning areas and are of the greatest economic
32 importance. Additionally, fall chinook salmon and steelhead trout spawn in the Hanford Reach.

34 Small interrupted streams, such as Rattlesnake and Snively springs, contain diverse biotic com-
35 munities and are extremely productive (Cushing and Wolf 1984). Dense blooms of watercress occur and
36 aquatic insect production is high compared with mountain streams (Gaines 1987). The macrobenthic
37 biota varies from stream to stream and is related to the proximity of colonizing insects and other factors.
38 Rattlesnake Springs is of ecological importance because it provides a source of water to terrestrial
39 animals in an otherwise arid part of the site. Snively Springs, located farther west and at a higher
40 elevation than Rattlesnake Springs, is a source of drinking water for terrestrial animals. The major
41 rooted aquatic plant, which in places may cover the entire width of the stream, is watercress (*Rorippa*
42 *nasturtium-aquaticum*). Isolated patches of bulrush (*Scirpus* sp.), spike rush (*Eleocharis* sp.), and cattail
43 (*Typha latifolia*) occupy less than 5 percent of the streambed.

4.6.4 Threatened and Endangered Species

The federal Endangered Species Act (16 USC 1531-1544) defines endangered species as plants and animals in danger of extinction within the foreseeable future throughout all or a significant portion of its range. Threatened species are those likely to become endangered within the foreseeable future throughout all or a significant portion of its range. Candidate species are plants and animals with a status of concern, but more information is needed before they can be proposed for listing.

No plants or mammals on the federal list of threatened and endangered wildlife and plants (50 CFR 17) are known to occur on the Hanford Site. However, the bald eagle and two species of fish (steelhead and spring-run chinook salmon), currently found on the federal list of threatened and endangered species, are present on the Hanford Site on a regular basis. Surveys of the 200 Areas (Sackschewsky 2002a, b) and Area C (Sackschewsky 2002b) revealed no federal or state threatened or endangered species (see Appendix I).

Federally listed threatened, endangered, candidate species (50 CFR 17), and species of concern (http://www.wa.gov/wdfw/wlm/diversty/soc/adv_search.htm) and threatened and endangered species listed by Washington State (Washington Natural Heritage Program 2002) identified on the Hanford Site are shown in Table 4.12. Several candidate species of plants and animals are under consideration for formal listing by the federal government and Washington State. The FWS annually reviews the status of candidate species for listing under the Endangered Species Act. The results of these reviews are posted on the FWS homepage <http://www.fws.gov>. Several federal plant and animal species of concern require further information before the FWS can decide whether the species should be considered for formal listing (http://www.wa.gov/wdfw/wlm/diversty/soc/adv_search.htm). Anadromous fish are reviewed and listed by the National Marine Fisheries Service (NMFS) (<http://www.nwr.noaa.gov>).

Washington State defines endangered species as wildlife species native to the state of Washington that are seriously threatened with extinction throughout all or a significant portion of their ranges within the state. Threatened species include wildlife species native to the state of Washington that are likely to become an endangered species within the foreseeable future throughout a significant portion of their ranges within the state (WAC 232-12-297). A State of Washington sensitive species is a wildlife species native to the state that is vulnerable or declining and is likely to become endangered or threatened throughout a significant portion of its range within the state without cooperative management or removal of threats. The common loon (*Gavia immer*) is the only Washington State sensitive animal species found on the Hanford Site. Table 4.13 lists the Washington State-designated candidate animal species that potentially are found on the Hanford Site and are under consideration for possible addition to the threatened or endangered list. A state candidate species is one that is being reviewed for possible listing as a state endangered, threatened, or sensitive species as specified in Washington Department of Fish and Wildlife Policy M-6001 (WDFW 1998).

Table 4.12. Federally Listed Threatened, Endangered, Candidate Species, and Species of Concern and Washington State-Listed Threatened and Endangered Species Occurring on the Hanford Site (Fitzner and Gray 1991, Landeen et al. 1992, U.S. Fish and Wildlife 2003, and Neitzel 2002a)

Common Name	Scientific Name	Federal	State ^(a)
Plants			
Columbia milkvetch	<i>Astragalus columbianus</i>	SC ^(b)	T ^(c)
dwarf evening primrose	<i>Camissonia (= Oenothera) pygmaea</i>		T
Hoover's desert parsley	<i>Lomatium tuberosum</i>	SC	T
loeflingia	<i>Loeflingia squarrosa</i> var. <i>squarrosa</i>		T
persistent sepal yellowcress	<i>Rorippa columbiae</i>	SC	T
Umtanum desert (wild) buckwheat	<i>Eriogonum codium</i>	C ^(d)	E ^(e)
White Bluffs bladderpod	<i>Lesquerella tuplashensis</i>	C	E
white eatonella	<i>Eatonella nivea</i>		T
Ute ladies'-tresses ^(g)	<i>Spiranthes diluvialis</i>	T	
Fish			
bull trout ^(g)	<i>Salvelinus confluentus</i>	T	
spring-run chinook	<i>Oncorhynchus tshawytscha</i>	E	C
steelhead	<i>Oncorhynchus mykiss</i>	E	C
Birds			
American white pelican	<i>Pelecanus erythrorhynchos</i>		E
bald eagle ^(f)	<i>Haliaeetus leucocephalus</i>	T	T
ferruginous hawk	<i>Buteo regalis</i>	SC	T
greater sage grouse	<i>Centrocercus urophasianus phaios</i>	C	T
olive-sided flycatcher	<i>Contopus cooperi</i>	SC	
sandhill crane	<i>Grus canadensis</i>		E
willow flycatcher	<i>Empidonax trailii</i>	SC	
yellow-billed cuckoo ^(g)	<i>Coccyzus americanus</i>	C	
Reptiles			
Northern sagebrush lizard	<i>Sceloporous graciosus</i>	SC	
(a) http://www.wa.gov/wdfw/ select Habitat, Priority Habitats and Species List, Species of Concern List, Endangered Species (WAC 232-12-297) (b) SC = Federal species of concern, 50 CFR 17 http://www.fws.gov . (c) T = Federal threatened species, 50 CFR 17 http://www.fws.gov . (d) C = Federal candidate species, 50 CFR 17 http://www.fws.gov . (e) E = Federal endangered species, 50 CFR 17 http://www.fws.gov . (f) Currently under review for change in status. (g) Not believed present on the Hanford Site, but identified by U.S. Fish and Wildlife Service 2003.			

Table 4.13. Washington State Candidate Animal Species Found on the Hanford Site (Fitzner and Gray 1991; Landeen et al. 1992; and Neitzel 2002a)

Common Name	Scientific Name
Molluscs	
giant Columbia River spire snail ^(a)	<i>Fluminicola (= Lithoglyphus) columbiana</i>
giant Columbia River limpet	<i>Fisherola (= Lanx) nuttalli</i>
Fish	
spring-run chinook ^(b)	<i>Oncorhynchus tshawytscha</i>
steelhead ^(b)	<i>Oncorhynchus mykiss</i>
Insects	
Columbia River tiger beetle ^(c)	<i>Cicindela columbica</i>
Birds	
burrowing owl ^(a)	<i>Athene cunicularia</i>
golden eagle	<i>Aquila chrysaetos</i>
Lewis' woodpecker	<i>Melanerpes lewis</i>
loggerhead shrike ^(a)	<i>Lanius ludovicianus</i>
merlin	<i>Falco columbarius</i>
northern goshawk ^(a,d)	<i>Accipiter gentilis</i>
sage sparrow	<i>Amphispiza belli</i>
sage thrasher	<i>Preoscotes montanus</i>
Reptiles	
striped whipsnake	<i>Masticophis taeniatus</i>
Mammals	
black-tailed jackrabbit	<i>Lepus californicus</i>
Merriam's shrew	<i>Sorex merriami</i>
Washington ground squirrel ^(e)	<i>Spermophilus washingtoni</i>
white-tailed jackrabbit	<i>Lepus townsendi</i>
(a) Information from Washington Department of Fish and Wildlife http://www.wa.gov/wdfw/ select Habitat, Priority Habitats and Species List, Species of Concern List) (WDFW Policy M-6001). (b) Federal endangered. (c) Probable, but not observed on the Hanford Site. (d) Reported, but seldom observed on the Hanford Site. (e) Federal candidate.	

1 Washington State considers pristine shrub-steppe habitat as a priority habitat because of its relative
2 scarcity in the state and because of its requirement as nesting/breeding habitat by several state and federal
3 species of concern (see Figure 4.21 for vegetation habitat coverage). Designation and characterization of
4 priority habitat serves to provide a basis for sound and defensible land management planning and assists
5 the DOE in implementing sound stewardship activities into site management to protect regulated species.
6

7 Table 4.14 lists Washington State plant species of concern that are currently listed as sensitive or are
8 in one of three monitored groups (Washington Natural Heritage Program 2002; Soll et al. 1999). The
9 Washington Natural Heritage Program established the ratings reported in Table 4.14 as Sensitive
10 (vulnerable or declining and could become Endangered or Threatened), Review 1 (more field work
11 needed), and Review 2 (unresolved taxonomic problems).
12

13 Figure 4.24 shows the general locations of species of concern on the Hanford Site prior to the
14 wildfire, and the 24 *Command Fire* coverage. In some areas the wildfire burn intensity was generally
15 low, allowing belowground portions of some perennial plants and seeds to survive. However, there were
16 some areas of high burn where the soil and seed bank may have been damaged. Most of the rare plants
17 are expected to recover within 1 to 3 years, although their populations may be reduced.
18

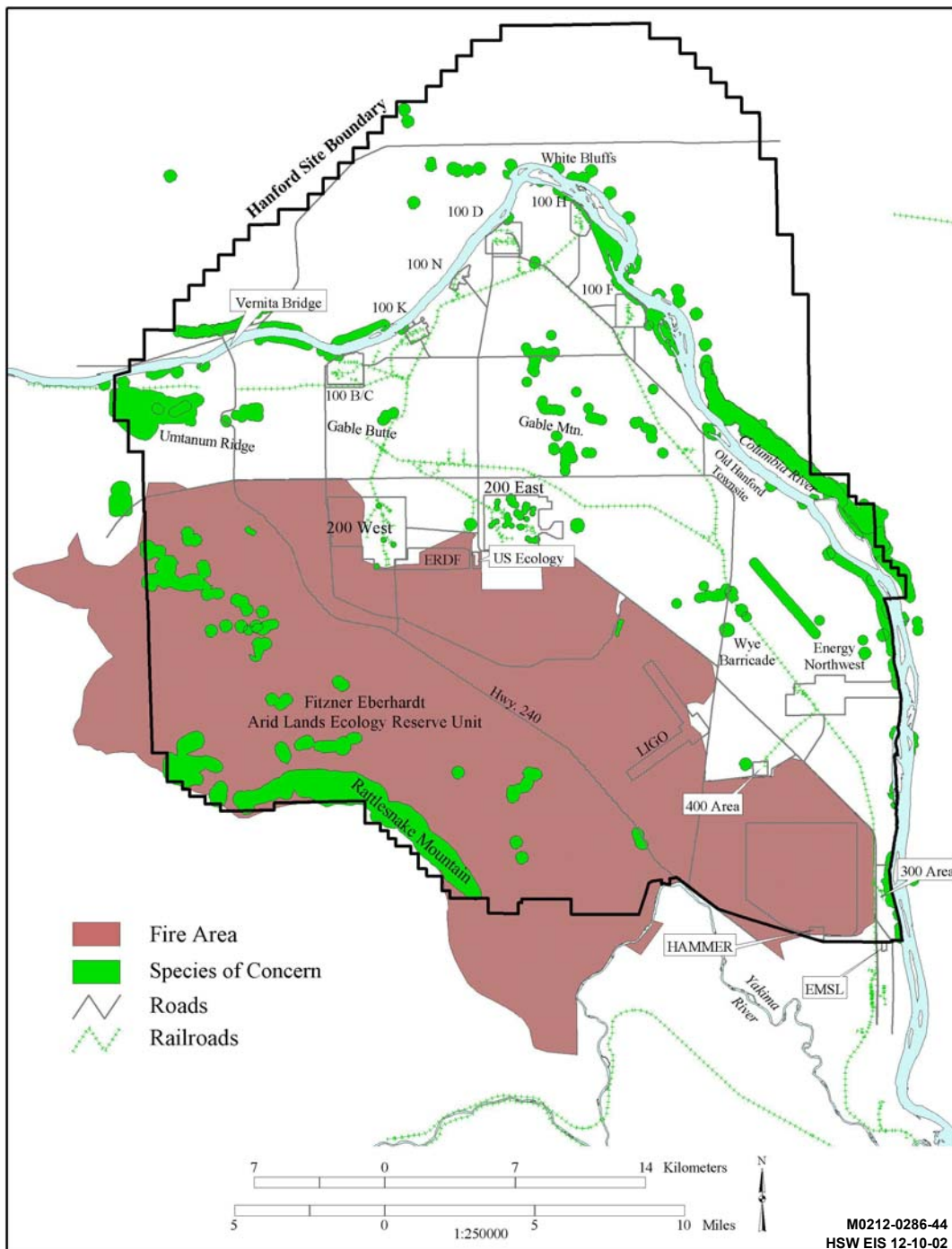
19 **200 Areas.** The annual review of the LLBGs was conducted in April of 2001 (Sackschewsky 2002a
20 Due to access restrictions, visual observations from the burial ground perimeters were performed. The
21 LLBGs include 218-E-10 and 218-E-12B in the 200 East Area, and 218-W-3A, 218-W-3AE, 218-W-4B,
22 218-W-4C, 218-W-5, and 218-W-6 in the 200 West Area. The western half of 218-W-6, the undeveloped
23 portion of 218-W-4C (along 16th Street), and the undeveloped portion of the 218-E-10 Burial Ground
24 (north of the existing powerline) were not reviewed during recent evaluations.
25

26 Crouching milkvetch (*Astragalus succumbens*) and stalked-pod milkvetch (*Astragalus sclerocarpus*),
27 State of Washington watch list species, were observed within 218-W-4C and the extreme western edge
28 of the 218-W-5 Burial Ground. Crouching milkvetch was also observed in the south end of the
29 218-W-6 Burial Ground. Piper's daisy (*Erigeron piperianus*), a State of Washington sensitive species
30 was noted in the 218-E-12B and 218-E-10 Burial Grounds in previous years.
31

32 Birds observed within the 200 East Area LLBGs include long-billed curlews (*Numenius americanus*),
33 killdeer (*Charadrius viociferus*), horned larks (*Eremophila alpestris*), Say's phoebe (*Sayornis saya*),
34 American robin (*Turdus migratorius*), American kestrel (*Falco sparverius*), western meadowlark
35 (*Sturnella neglecta*), and common raven (*Corvus corax*). Two bird species, loggerhead shrike
36 (*Lanius ludovicianus*) and sage sparrow (*Amphispiza belli*), Washington State candidate species, have
37 been sighted in the vicinity of the 218-W-4C Burial Grounds. Burrowing owls (*Athene cunicularia*),
38 Washington State candidate species, have been observed in the vicinity of the 218-W-6 Burial Grounds.

Table 4.14. Washington State Plant Species of Concern Occurring on the Hanford Site, as Determined by the Washington Natural Heritage Program 2002 (Neitzel 2002a)

Common Name	Scientific Name	State Listing
annual paintbrush	<i>Castilleja exilis</i>	R1
awned halfchaff sedge	<i>Lipocarpa</i> (= <i>Hemicarpha</i>) <i>aristulata</i>	R1
basalt milk-vetch	<i>Astragalus conjunctus</i> var. <i>rickardii</i>	R1
bristly combseed	<i>Pectocarya setosa</i>	W
brittle prickly pear	<i>Opuntia fragilis</i>	R1
Canadian St. John's wort	<i>Hypericum majus</i>	S
chaffweed	<i>Centunculus minimus</i>	R1
Columbia River mugwort	<i>Artemisia lindleyana</i>	W
coyote tobacco	<i>Nicotiana attenuata</i>	S
crouching milkvetch	<i>Astragalus succumbens</i>	W
desert dodder	<i>Cuscuta denticulata</i>	S
desert evening-primrose	<i>Oenothera caespitosa</i>	S
false pimpernel	<i>Lindernia dubia anagallidea</i>	R2
fuzzytongue penstemon	<i>Penstemon eriantherus whitedii</i>	R1
Geyer's milkvetch	<i>Astragalus geyeri</i>	S
grand redstem	<i>Ammannia robusta</i>	R1
gray cryptantha	<i>Cryptantha leucophaea</i>	S
Great Basin gilia	<i>Gilia leptomeria</i>	R1
hedge hog cactus	<i>Pediocactus simpsonii</i> var. <i>robustior</i>	R1
Kittitas larkspur	<i>Delphinium multiplex</i>	W
lowland toothcup	<i>Rotala ramosior</i>	R1
miner's candle	<i>Cryptantha scoparia</i>	R1
Piper's daisy	<i>Erigeron piperianus</i>	S
Robinson's onion	<i>Allium robinsonii</i>	W
rosy balsamroot	<i>Balsamorhiza rosea</i>	W
rosy pussypaws	<i>Calyptridium roseum</i>	S
scilla onion	<i>Allium scilloides</i>	W
shining flatsedge	<i>Cyperus bipartitus (rivularis)</i>	S
small-flowered evening-primrose	<i>Camissonia</i> (= <i>Oenothera</i>) <i>minor</i>	R1
small-flowered nama	<i>Nama densum</i> var. <i>parviflorum</i>	R1
smooth cliffbrake	<i>Pellaea glabella simplex</i>	W
Snake River cryptantha	<i>Cryptantha spiculifera</i> (= <i>C. interrupta</i>)	S
southern mudwort	<i>Limosella acaulis</i>	W
stalked-pod milkvetch	<i>Astragalus sclerocarpus</i>	W
Suksdorf's monkey flower	<i>Mimulus suksdorfii</i>	S
winged combseed	<i>Pectocarya linearis</i>	R1
The following species have been reported as occurring on the Hanford Site, but the known collections are questionable in terms of location or identification, and have not been collected recently on the site.		
Beaked spike-rush	<i>Eleocharis rostellata</i>	S
dense sedge	<i>Carex densa</i>	S
few-flowered collinsia	<i>Collinsia sparsiflora</i> var. <i>bruciae</i>	S
giant helleborine	<i>Epipactis gigantea</i>	S
medic milkvetch	<i>Astragalus speirocarpus</i>	W
orange balsam	<i>Impatiens aurella</i>	R2
Palouse milkvetch	<i>Astragalus arrectus</i>	S
Palouse thistle	<i>Cirsium brevifolium</i>	W
porcupine sedge	<i>Carex hystericina</i>	S
Thompson's sandwort	<i>Arenaria franklinii thompsonii</i>	R2
S = Sensitive (i.e., taxa vulnerable or declining) and could become endangered or threatened without active management or removal of threats.		
R1 = Taxa for which there are insufficient data to support listing as threatened, endangered, or sensitive (formerly monitor group 1).		
R2 = Taxa with unresolved taxonomic questions (formerly monitor group 2).		
W = Taxa that are more abundant or less threatened than previously assumed (formerly monitor group 3).		



EMSL – Environmental and Molecular Sciences Laboratory
 ERDF – Environmental Restoration Disposal Facility
 HAMMER – Hazardous Materials Management and Emergency Response
 mtn. - mountain

Figure 4.24. Species of Concern on the Hanford Site and the 24 Command Fire Area (after DOE-RL 2001 and BAER 2000)

A 1998 amendment to the Fish and Conservation Act directs the USFWS to identify species, subspecies, and populations of all migratory non-game birds that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act (USFWS 2002). These birds, designated as Birds of Conservation Concern, also include recently delisted species. Table 4.15 lists Birds of Conservation Concern, as recognized by the USFWS, which have been observed on the Hanford Site.

Table 4.15. Birds of Conservation Concern Observed on the Hanford Site (USFWS 2002).

Common Name	Scientific Name
Swainson's hawk	<i>Buteo swainsoni</i>
ferruginous hawk	<i>Buteo regalis</i>
golden eagle	<i>Aquila chrysaetos</i>
peregrine falcon	<i>Falco peregrinus</i>
prairie falcon	<i>Falco mexicanus</i>
greater sage grouse ^(a)	<i>Centrocercus urophasianus phaios</i>
American avocet	<i>Recurvirostra americana</i>
solitary sandpiper	<i>Tringa solitaria</i>
long-billed curlew	<i>Numenius americanus</i>
marbled godwit	<i>Limosa fedoa</i>
sanderling	<i>Calidris alba</i>
Wilson's phalarope	<i>Phalaropus tricolor</i>
flamulated owl	<i>Otus flammeolus</i>
burrowing owl	<i>Athene cunicularia</i>
Lewis' woodpecker	<i>Melanerpes lewis</i>
loggerhead shrike	<i>Lanius ludovicianus</i>
Brewer's sparrow	<i>Spizella breweri</i>
sage sparrow	<i>Amphispiza belli</i>

(a) Endangered Species Act candidate.

4.6.5 Microbiotic Crusts

Microbiotic crusts generally occur in the top 1 to 4 mm (0.04 to 0.16 in.) of soil and are formed by living organisms and their by-products, creating a crust of soil particles bound together by organic materials. Microbiotic crusts are common in the semi-arid Columbia Basin, where the dominant form tends to be green algae (Johansen et al. 1993). The functions of microbiotic crusts include: soil stability and protection from erosion, fixation of atmospheric nitrogen, nutrient contribution to plants, influencing soil-plant water relations, increasing water infiltration, seedling germination, and plant growth. The ecological roles of microbiotic crusts depend on the relative cover of various crustal components. Carbon inputs are higher when mosses and lichens are present than when the crust is dominated by cyanobacteria.

1 Nitrogen inputs are higher with greater water infiltration. Soil surface stability is related to cyanobacterial
2 biomass as well as total moss and lichen cover (Belnap et al. 2001). The lichen and mosses of the
3 Hanford Site were surveyed and evaluated by Link et al. (2000). They found 29 soil lichens in 19 genera
4 and 6 moss species in 4 genera. Twelve (41 percent) lichen species are of the crustose growth form (flat
5 and firmly attached to the substrate), eight (28 percent) are squamulose (having small, flat scales that do
6 not adhere tightly to substrate), seven (24 percent) are foliose (having leaf-like lobes, attached in the
7 center to substrate by clusters of rhizomes) and two (7 percent) are fruticose (plant-like growth attached at
8 one point).

9 10 **4.6.6 Biodiversity**

11
12 The Hanford Site is located within the Columbia Basin Ecoregion, an area that historically included
13 over 6 million ha (14.8 million acres) of steppe and shrub-steppe vegetation across most of central and
14 southeastern Washington State, as well as portions of north-central Oregon. The pre-settlement
15 vegetation consisted primarily of shrubs, perennial bunchgrasses, and a variety of forbs. An estimated
16 60 percent of shrub-steppe in Washington has been converted to agriculture or other uses. Much of what
17 remains is in small parcels, in shallow rocky soils, or has been degraded by historic land uses (mostly
18 livestock grazing) (TNC 1999).

19
20 The Hanford Site retains some of the largest remaining blocks of relatively undisturbed shrub-steppe
21 in the Columbia Basin Ecoregion. Hanford's importance as a refuge for the shrub-steppe ecosystem is
22 not solely size-related, however. The presence of a high diversity of physical features and examples of
23 rare, undeveloped deep and sandy soil has led to a corresponding diversity of plant and animal commu-
24 nities. Many places on the Hanford Site are relatively free of non-native species and are extensive enough
25 to retain characteristic populations of shrub-steppe plants and animals that are absent or scarce in other
26 areas. Because of its location, the Site provides important connectivity with other undeveloped portions
27 of the ecoregion.

28 29 **4.7 Cultural, Archaeological, and Historical Resources**

30
31 The Hanford vicinity is one of the most culturally rich resource areas in the western Columbia
32 Plateau. The site comprises a series of cultural landscapes containing the cumulative record of multiple
33 occupations by Native and non-Native Americans. These landscapes contain numerous well-preserved
34 archaeological sites representing prehistoric, ethnographic, and historic periods. Period resources include
35 sites with cultural materials that are thousands of years old, traditional cultural places, and buildings and
36 structures from the pre-Hanford, Manhattan Project, and Cold War eras. The National Historic
37 Preservation Act (16 USC 470), the Native American Graves Protection and Repatriation Act (25 USC
38 3001), the Archaeological Resources Protection Act, and the DOE American Indian Policy (DOE 2000b),
39 among other legislation and guidelines, require the identification and protection of areas and resources of
40 concern to the Native American community (see Sections 6.13 and 6.14).